SECTION C Description/Specs/Work Statement

STATEMENT OF WORK (SOW)
FOR
DESIGN AND FABRICATION OF A PROTOTYPE FULL SCALE HEAT PIPE/BLEED AIR COOLER "HEAT EXCHANGER"

1. Background

The Navy has identified a need for an improved Bleed Air Cooler ("BAC"). Certain gas turbine powered ships are currently equipped BACs, designed to handle temperatures as high as 925ºF, that utilize seawater as a coolant. These BACs experience numerous problems, including extensive fouling due to precipitation of solids in the seawater coolant, undetected leakage or catastrophic failure and subsequent damage to other system components. Preliminary studies undertaken by, or under the direction of, the Naval Surface Warfare Center, Carderock Division (NSWCCD), Philadelphia, Advanced Auxiliary Machinery Branch (Code 983) have indicated that incorporating heat pipe technology into a new design for BACs could provide a solution to these problems.

Heat pipes would provide an additional heat transfer boundary between the incoming bleed air stream and the seawater coolant. The intermediate heat transfer fluid, contained in a hermetically sealed pipe, would maintain the heat pipe surface at a low enough temperature to prevent salt scaling caused by the seawater heat sink medium. Moreover, the additional heat transfer boundaries between the seawater coolant stream and the bleed air stream would allow for early detection of corrosion-related problems while avoiding catastrophic failure due to leakage of fluid between the two streams.

Preliminary design studies have demonstrated the feasibility of the concept and provided sufficient data to justify proceeding to the design and fabrication of a full-scale prototype of the new type of cooler.

Figures 1 and 2 in Appendix A show a typical shell and tube design heat exchanger (similar to the BACs currently in use) and a concept design of the proposed new type of heat pipe/bleed air cooler heat exchanger ("HP-BAC"), respectively.

2. Objectives

2.1 The contractor shall finalize the design for the prototype HP-BAC and then fabricate a full-scale protoype HP-BAC ready for installation and testing onboard a US Navy surface combatant.

2.2 The contractor shall develop cost projections for a production run of the final HP-BAC design. These costs are to be based on alternative production runs of 10 units per year, 25 units per year and 50 units per year.

3. Scope of Work

The contractor shall provide services, incidental materials, and personnel necessary to support the contract objectives. The obligations of the contractor shall include the following tasks:

3.1 Conduct a ship survey at Norfolk Naval Base, Norfolk, VA to assess the operational requirements for a shipboard HP-BAC, identify space limitations and observe the inter-relationship of the cooler with other ship systems. (NSWCCD shall make arrangements for the ship survey and coordinate with the individual ship to be visited.)

3.2 Provide mathematical model, structural and thermal analysis of the HP-BAC and verify through model calculations that the design will meet the performance requirements identified in Table 1 of Appendix A.

3.3 Finalize drawing package in electronic format of the HP-BAC before fabrication commences. The drawing package shall be of sufficient detail to permit construction of individual components as well as the entire HP-BAC. The drawing package should also include details for optional instrumentation of the prototype HP-BAC. The final design of the prototype HP-BAC for fabrication should take into account information provided by NSWCCD-Philadelphia to the contractor from the previous studies of the HP-BAC concept.

3.4 Fabricate an HP-BAC (full scale prototype) meeting the performance requirements identified in Table 1 ready for installation on a surface combatant. (Installation and onboard testing will be covered under a separate contract). The prototype shall be fabricated out of the materials indicated on Table 2 of Appendix A. In fabricating the HP-BAC prototype, the contractor shall comply, insofar as possible, with all references and documents cited in Table 3 of Appendix A and the requirements listed below:

3.4.1 Welding and allied processes. Welding shall be in accordance with MIL-STD-278. Brazing may be used where applicable. For brazing nickel-containing alloys such as composition 70-30 or 90-10 copper-nickel, grade IV silver-base brazing alloy in accordance with QQ-B-654 shall be used. Brazing of piping joints including root connections shall be accomplished in accordance with NAVSEA 0900-P-001-7000.

3.4.2 Weld strength. For calculating the strength of welded joints, weld efficiencies shall be in accordance with MIL-STD-278.

3.4.3 Piping connections. Inlet and outlet connections for seawater shall be flanged. Unless otherwise specified, flanges shall be type PR, plain 250 pounds, ¼ to 12-inch size, inclusive, of MIL-PRF-20042, with cast nozzles conforming to the dimensions shown on Drawing 810-1385915. For fabricated nozzles, in lieu of the plain 250-pound flange of MIL-PRF-20042, slip-on-flanges of the same dimensions in diameter, thickness, and drilling will be acceptable.

3.4.4 Hydrostatic pressure test. Unless otherwise specified the air side and waterside of the cooler shall each be hydrostatically tested at 1-1/2 times the design pressure or 100 lb/in^2, whichever is greater. Joints shall be bone dry after pressure has been held for 15 minutes. Clean fresh water shall be used unless specified otherwise.

3.5 It is understood that since this is a prototype, certain changes may be required as fabrication progresses. Although it is not necessary for the prototype HP-BAC to pass shock and vibration qualification testing, the design for the final production model should take into account the need for HP-BACs to be installed on the fleet to pass shock and vibration testing.

3.6 Manufacturer's operational check: Contractor must conduct an operational check of not less than 4 hours duration before delivery of the full scale prototype HP-BAC to determine any shortfalls in prototype design or fabrication. Contractor shall also recommend instrumentation to be used to fully characterize performance of the HP-BAC during onboard, full performance testing (which will be conducted under a separate contract).

3.7 Develop a projection of the cost per unit to produce full-scale HP-BACs based upon the revised design parameters of the HP-BAC developed by the contractor, based on alternative production runs of 10 units per year, 25 units per year and 50 units per year.

3.8 Attend meetings at NSWC to review progress on the tasks delineated above in accordance with the Plan of Action and Milestones (POA&M) developed for this contract.

3.9 Provide a letter-type final report describing the work accomplished. This report shall discuss the results of the fabrication of test articles, variables that could affect the cost of fabricating multiple units, revisions to be made to the geometry and design parameters for fabricating production models, and a list of tasks or additional work required to fabricate a production, full-scale HP-BAC.

4. Travel/Deliverables/Schedule (POA&M)

4.1 The Government will develop and provide to the contractor a Plan of Action and Milestone (POA&M) setting forth target dates for various contract objectives, including dates for the progress meetings described in paragraph 4.3 and delivery dates for the deliverables described in paragraph 4.4.

4.2 For planning, scheduling, and team coordination, a NSWCCD-developed Microsoft Project Gantt chart of the test plan will be used for performing and tracking the work to be completed by NSWCCD and the contractor. NSWCCD will maintain and update the chart as required by the project and will provide copies to the contractor.

4.3 Contractor will be required to travel to accomplish the contract objectives. Travel required under this contract is expected to be as follows:

Item	Purpose	Location	People (per trip)	Trips	Days (per trip)
1	Progress Meeting	NSWCCD Philadelphia, PA	3	2	1
2	Ship Survey	Norfolk Navy Base Norfolk, VA	3	1	5

4.4 Contractor will be required to produce the following deliverables under this contract:

Item	Performance Description	SOW REF	Unit	Delivery (Days after Award)
01	Ship Survey Report	3.1	1 letter report	35
02	Mathematical Model and Verified Calculations for Structural and Thermal Analysis	3.2	1 technical report	60
03	Final HP-BAC Prototype Drawing Package	3.3	1 electronic report	90
04	Full-Scale Prototype HP-BAC	3.4	1 prototype	200
05	Projection of Production Costs	3.7	1 report	200
06	Final Report	3.9	1 report	230

5. Government Furnished Information and Materials:

5.1 The Government will provide the contractor with: on-site access at Philadelphia and Norfolk Naval Base (for the events described in paragraph 4.3); current bleed air cooler specifications; welding specifications; and material specifications.

5.2 The Government shall, within 30 days after award of the contract, provide the contractor with the raw materials designated as items 1, 4, 5, 6 and 7 in Table 2 of Appendix A required to fabricate the heat pipes, shell, and tube sheet for the prototype HP-BAC.

6. Performance and Deliveries:

6.1 Period of Performance: The period of performance for this contract will commence on the date of contract award and end 230 days after the date of contract award.

6.2 Place of Performance: The primary place of performance will be the contractor's facilities, but travel will be required as stated in paragraph 4.3.

6.3 Place of Delivery:

6.3.1 Except as stated in 6.3.2, all deliverables under this contract are to be delivered to:
Naval Surface Warfare Center
Philadelphia Business Center
5001 S. Broad Street
Philadelphia, PA 19112-1403
Marked for: Code 983 (Mr. Denis Colahan)

6.3.2 The full scale prototype HP-BAC is to be delivered, FOB Destination, to Norfolk, Va. The exact location and any further delivery instructions will be provided to the contractor 30 days before delivery.

6.4 Technical Point of Contact: The Technical Point of Contact (TPOC) for this contract is Mr. Denis Colahan, Code 983 (215-897-7231).

6.5 Security Requirements: Unclassified.

APPENDIX A

TABLE 1: HP-BAC DESIGN PERFORMANCE DATA		
PERFORMANCE DATA	**BLEED AIR COOLER**	
COOLER CHARACTERISTICS	**AIR SIDE**	**WATER SIDE**
FLUID CIRCULATED	Air (2450 SCFM)	Seawater
FLOW RATE (LB/HR)	11,231	46,350
INLET TEMPERATURE (ºF)	925	85
OUTLET TEMPERATURE (ºF)	425	116.3
PRESSURE DROP (ALLOW/CALC) (PSI)	2.46/1.50	3.000/1.406
VELOCITY AT INLET FLANGE FACE (FT/SEC)	198.9	4.14
MAX INTERNAL VELOCITY (FT/SEC)	85 to 90	3.21
NUMBER OF PASSES	1	1
DESIGN PRESSURE (PSIG)	100	50
TEST PRESSURE (PSIG)	150	100
DESIGN TEMPERATURE (º F)	925	300
LOG MEAN TEMPERATURE DIFFERENTIAL (LMTD) (ºF)	535.878	
HEAT TRANSFER RATE CLEAN (BTU/HR/SQ FT/ºF)	19.2	
HEAT TRANSFER SURFACE AREA (SQ FT)	140.59	
HEAT EXCHANGE (BTU/HR) (APPROX)	1,423,800	
WEIGHT DRY/FULL OF WATER (LBS)	800/900	
MAX LENGTH OF COOLER	not to exceed 7.5 feet	
MAX DIAMETER OF COOLER	not to exceed 16 inches	
HEAT PIPE CHARACTERISTICS:		
HEAT PIPE WORKING FLUID	water	
MAX HEAT LOAD/HEAT PIPE (WATTS/PIPE)	2863	
MAX WATER SIDE PIPE WALL TEMP (ºF) WITH 925º F INLET AIR	172	
MAX WATER SIDE PIPE WALL TEMP (ºF) WITH 700º F INLET AIR	150	
SINGLE PIPE THERMAL RESISTANCE (ºC/WATT)	0.06	

TABLE 2: HP-BAC MATERIALS			
Item	**Parts**	**Materials**	**Specification**
1	Shell	copper-nickel alloy, composition 70-30	MIL-T15005 or MIL-T-22214
2	Stay bolts and shell side baffles	stainless steel (AISI) grade 347)	ASTM A 240 or ASTM A 473 or ASTM F 593
3	Water-boxes	copper alloy C90300 or valve bronze, alloy C92200; or copper-nickel alloy, composition 70-30	ASTM B 584 or ASTM B 61 MIL-C-15726
4	Heat pipe support sheets/tube sheet	copper-nickel alloy, composition 70-30	MIL-C-15726
5	Tube sheet bushing	copper-nickel alloy, composition 70-30	MIL-C-15726
6	Heat pipes	copper-nickel alloy, composition 70-30	MIL-T-15005 or MIL-T-22214
7	Fins air & water side	copper-nickel alloy, composition 90-10	MIL-C-15726
8	Threaded fasteners	nickel alloy	MIL-S-1222
9	Zinc protectors	Zinc	MIL-A-19521
10	Plugs, zinc support	copper-nickel alloy, composition 70-30	MIL-C-15726
11	Gaskets	rubber sheet, cloth insert; or non-asbestos sheet, compresses	HH-P-151 HH-P-46 MIL-G-24696
12	Pipe plugs and adapters	valve bronze, alloy C92200, copper alloy C90300; or copper-nickel alloy, composition 70-30	ASTM B 505 MIL-C-15726 or MIL-C-24679
13	Zinc inspection covers	Copper-nickel alloy, composition 90-10, copper alloy C90300; or valve bronze, alloy C92200	MIL-C-15726 ASTM B 584 or ASTM B 61

TABLE 3 – References and Applicable Documents

The following specifications, standards and handbooks form a part of this document to the extent specified herein:

SPECIFICATIONS		
FEDERAL		
	HH-P-46E(2)	Packing; Asbestos, Sheet, Compressed
	HH-P-151F	Packing; Rubber-Sheet, Cloth-Insert
	QQ-B-654	Brazing Alloys, Silver
MILITARY		
	MIL-A-19521B	Anode Retaining Support Plugs and Anode Selection and Installation Design Criteria for Shipboard Condensers and Heat Exchanger
	MIL-C-15726F	Copper-Nickel Alloy, Sheet, Plate, Strip, Bar, Rod and Wire
	MIL-C-24679	Copper-Nickel Alloy Forgings and Forging STDCL
	MIL-DTL-1222J	Studs, Bolts, Screws and Nuts for Applications Where a High Degree of Reliability is Required; General Specification For
	MIL-G-24696B	Gasket, Sheet, Non-Asbestos
	MIL-STD-278F	Welding and Casting Standard
	MIL-PRF-20042E	Flange, Pipe, Bronze (Silver Brazing)
	MIL-T-15005F	Tubes, Condenser and Heat Exchanger, Copper-Nickel Alloys (UNS C70600 & C71500)
	MIL-T-22214C	Tube, Condenser and Heat Exchanger with Integral Fins (UNS Alloy Nos. C17500, C70600, C12200)
DRAWINGS		
NAVAL SEA SYSTEMS COMMAND (NAVSEA)		
	810-1385915	Fittings, Pipe, Composition, Flanged. 100P.S.I. Max at 425ºF Max. for all Services
PUBLICATIONS		
NAVAL SEA SYSTEMS COMMAND (NAVSEA)		
	0900-P-001-7000	Piping Systems Brazed, Fabrication and Inspection
AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)		
	Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1 – Rules for Construction of Unfired Pressure Vessels	

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)	
ASTM-A473	Steel Forgings, Stainless
ASTM-A240/ 240M	Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
ASTM-B61	Castings, Steam or Valve Bronze
ASTM-B505/ 505M	Castings, Copper Alloy, Continuous
ASTM-B584	Castings, Copper Alloy Sand, for General Applications
ASTM-F593	Bolts, Stainless Steel, Hex Cap Screws and Studs

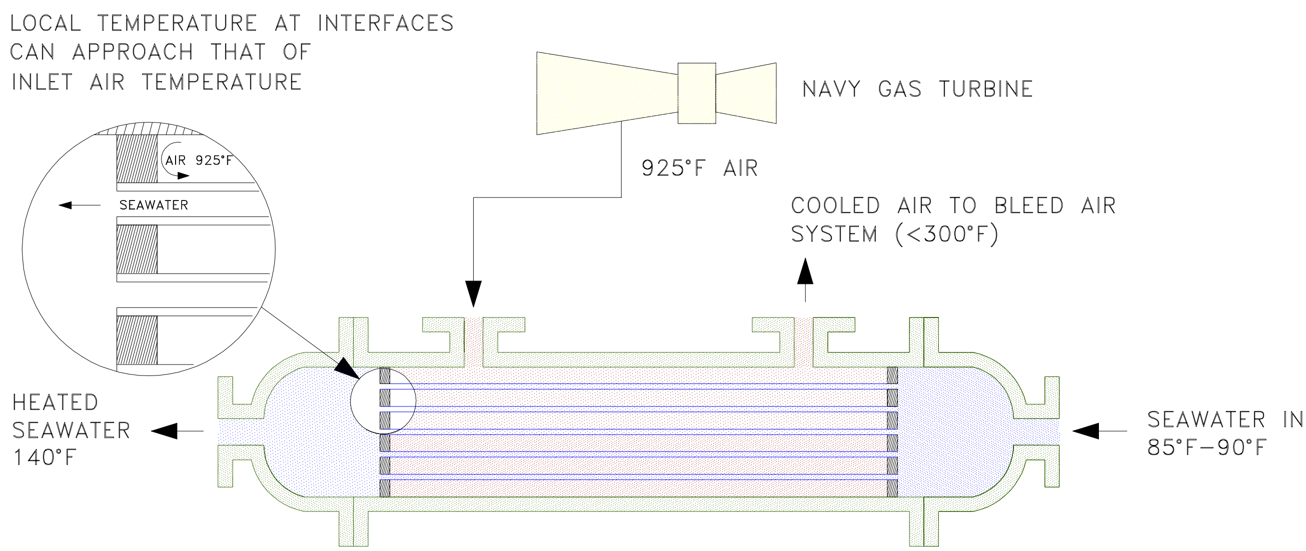
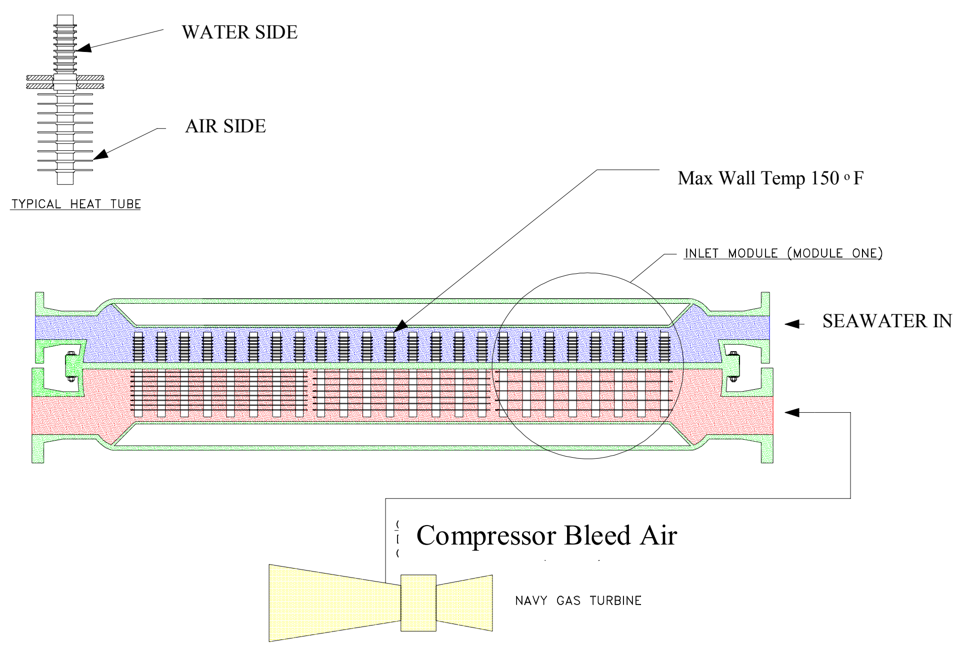


Figure 1

Shows a current bleed air cooler design and how localized wall temperature will approach inlet gas temperatures.



Concept design of a full scale heat pipe heat exchanger

FIGURE 2